27. Passage of particles through matter

Figure 27.18: An EGS4 simulation of a 30 GeV electron-induced cascade in iron. The histogram shows fractional energy deposition per radiation length, and the curve is a gamma-function fit to the distribution. Circles indicate the number of electrons with total energy greater than 1.5 MeV crossing planes at $X_0/2$ intervals (scale on right) and the squares the number of photons with $E \geq 1.5$ MeV crossing the planes (scaled down to have same area as the electron distribution).

which is in general less than the total track length $T$. Practical devices are sensitive to electrons with energy above some detection threshold $E_d$, and $T_d = T F(E_d/E_c)$. An analytic form for $F(E_d/E_c)$ obtained by Rossi [4] is given by Fabjan [53]; see also Amaldi [54].

The mean longitudinal profile of the energy deposition in an electromagnetic cascade is reasonably well described by a gamma distribution [55]:

$$\frac{dE}{dt} = E_0 b \frac{(bt)^{a-1}e^{-bt}}{\Gamma(a)} \quad (27.31)$$

The maximum $t_{\text{max}}$ occurs at $(a-1)/b$. We have made fits to shower profiles in elements ranging from carbon to uranium, at energies from 1 GeV to 100 GeV. The energy deposition profiles are well described by Eq. (27.31) with

$$t_{\text{max}} = (a-1)/b = 1.0 \times (\ln y + C_j), \quad j = e, \gamma, \quad (27.32)$$

where $C_e = -0.5$ for electron-induced cascades and $C_\gamma = +0.5$ for photon-induced cascades. To use Eq. (27.31), one finds $(a-1)/b$ from Eq. (27.32) and Eq. (27.30), then finds $a$ either by assuming $b \approx 0.5$ or by finding a more accurate value from Fig. 27.19.

The results are very similar for the electron number profiles, but there is some dependence on the atomic number of the medium. A similar form for the electron number maximum was obtained by Rossi in the context of his “Approximation B,” [4] (see Fabjan’s review